

Oral presentations

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AN EVALUATION OF THE PRELOAD INDEPENDENCE OF THE NEW ECHOCARDIOGRAPHIC INDICES OF DIASTOLIC FUNCTION IN PATIENTS UNDERGOING HAEMODIALYSIS

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Assessment of mitral annular motion velocities by tissue Doppler imaging (TDI) and the propagation velocity of early diastolic filling by colour M-mode have been proposed as preload-independent indices of diastolic function. The aim of this study, performed in patients with chronic renal failure and volume overload, was to determine the effects of preload reduction by haemodialysis on these new echocardiographic indices and compare them with standard mitral inflow variables. The study group comprised 16 patients in sinus rhythm, of mean age 57 years (range 29–75 years) without regional wall motion abnormalities or significant pericardial or valvular disease. Subjects underwent echocardiography 30 minutes prior to and 30 minutes following haemodialysis.

Following dialysis there were significant reductions in weight (68.9 ± 18.0 to 67.3 ± 17.6 kg, $p < 0.001$), left ventricular end diastolic diameter (5.0 ± 0.7 to 4.7 ± 0.8 cm, $p = 0.01$), left atrial diameter (4.7 ± 0.6 to 4.5 ± 0.5 cm, $p = 0.001$), peak mitral E velocity (86 ± 19 to 73 ± 24 cm/s, $p = 0.005$) and E/A ratio (1.2 ± 1.0 to 1.1 ± 1.0 , $p = 0.02$), consistent with a preload reduction in cardiac volumes and the recognised preload-dependence of mitral inflow indices. By contrast, there was no change after dialysis in mitral annular early or late diastolic velocities by TDI from either lateral or septal walls ($p = 0.25$ for all), although the TDI early diastolic velocity from the lateral annulus was consistently greater than that from the septal annulus ($p < 0.0001$). There was a trend to a decrease in colour M-mode propagation velocity after dialysis (61 to 56 cm/s, $p = 0.09$).

In conclusion, our findings suggest that TDI of mitral annular motion provides an echocardiographic measurement of diastolic function which is independent of preload, but raise the possibility that colour M-mode propagation velocity may not be preload-independent.

ECHOCARDIOGRAPHIC TISSUE CHARACTERISATION: A VALIDATION STUDY

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The cyclical variation in radiofrequency integrated backscatter (RFIB) has been shown to vary in different cardiac conditions. This raw signal may offer functional and structural information about the myocardium. We have explored the use of another relatively unprocessed signal (r.theta) in distinguishing physiological from pathological left ventricular hypertrophy (LVH). Echocardiograms from 25 individuals have been analysed (see table). Parasternal long axis views were obtained using an ATL5000 and analysed offline using the HDI-Lab computer program. Four circular regions of interest (ROI) each 0.5 cm in diameter were placed in the PW and moved manually to track the myocardium. The r.theta amplitude for 20–30 time points per cardiac cycle was averaged for three cardiac cycles and processed by CycVar 1.0 (J.G. Miller 1999). The smoothed output from this computer program provides the magnitude of cyclical variation and the timing of the nadir as a percentage of systolic time. Signal in the table is

| Group | Signal at ED | Signal at ES | Cyclical variation | Delay to nadir (% systole) |
|---------------|--------------|--------------|--------------------|----------------------------|
| Normal (n=6) | 10.8±4.9 | 4.9±2.2 | 4.5±4.0 | 117±37 |
| Athlete (n=9) | 11.5±4.8 | 6.0±2.6 | 4.4±2.4 | 96±9 |
| HTN (n=10) | 8.9±5.8 | 6.0±4.7 | 2.7±1.5 | 121±25 |

expressed in arbitrary units of amplitude (as in HDI-Lab). Cyclical variation was demonstrated in all patients and was statistically significant in 18 / 25 subjects. For the group as a whole the amplitudes were 10.3 ± 5.2 at end diastole (ED) and 5.7 ± 3.4 at end systole (ES) ($p < 0.001$). Cyclical variation was reduced in the hypertensive (HTN) group and the time to nadir was shorter in athletes than either normals or HTN (not statistically significant). The latter finding may be explained by more rapid contraction in the athletic group. These findings are similar to previous studies using RFIB.

SIMPLE LESSONS IN ECHO SERVICE UTILITY

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Background: The increasing demand on echo services has been well documented, resulting in calls for more resources. However we suspect that ineffective test requesting is contributing to these demands.

Methods: All OP adult echo studies over a 3-month period were assessed for: the reasons for the request, the clinicians making the requests, and whether the tests were repeats. The clinical data/reasons given were categorised as "functional" (symptom) or "structural" (targeted at a cardiac process). Requests due to Arrhythmia/Palpitation were examined in more detail.

Results: 256 requests were studied. 171 (66%) requests cited a "structural" reason for the investigation, with native valve assessment (88) and LV contractility (74) as the dominant reasons given. 85 (33%) of requests gave only "functional" request data, including unspecified arrhythmia (35), HBP (12), breathlessness (16) and unspecified murmur (19). 107 (42%) of the patients had had previous investigations, with 35 (14%) having 4 or more previous echos. Service utilisation was dramatically skewed with one consultant team requesting 138 (54%) of all studies and some consultants despite having access to general medicine intake, hardly using the echocardiography service at all. Assessment of the reasons for requesting echo due to arrhythmia showed few indicative symptoms in clinical summaries and rest ECG abnormalities were rare.

Conclusion: A third of requests for echocardiography were based on symptoms only, lacked clinical reason for request, and were not targeted at a specific cardiac process that could be answered with echocardiography. The number of repeat scans suggests routine referral for investigation without change in clinical symptoms. The skewed distribution of requesting data, staff and repeats, suggests a lack of consistency of approach in the use of the echocardiography service. This is likely to be a national as well as a local pattern.

RIGHT VENTRICULAR FUNCTION IS AN IMPORTANT DETERMINANT OF EXERCISE CAPACITY IN PATIENTS WITH CHRONIC HEART FAILURE

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Exercise intolerance in chronic heart failure (CHF) has numerous determinants. Traditionally, the interest of researchers has been focused on the role of left ventricular (LV) systolic and diastolic function and peripheral factors. In this study we tested a number of clinical and echocardiographic parameters, including those of right ventricular (RV) function, as determinants of exercise capacity in CHF patients.

Methods: The study population consisted of 111 patients with clinically stable CHF (mean age 67 ± 11 yrs) and a mean LV ejection fraction of 35% (range 17–45%). The study patients underwent full echocardiographic examination including colour-coded tissue Doppler imaging. RV systolic function was assessed by RV area shortening fraction in a 4-chamber apical view, RV diastolic function was assessed by the Doppler study of transtricuspid flow. Peak oxygen consumption (VO_2) was measured during symptom-limited maximal treadmill-based exercise tests with respiratory gas analysis.

Results: Peak VO_2 in CHF patients was 22.17 ± 5.58 ml/kg/min. Nineteen different clinical and echocardiographic variables correlated significantly with peak VO_2 , including age, heart rate, LV ejection fraction, left atrial active emptying fraction, RV area shortening fraction, Doppler parameters of LV and RV diastolic filling, mitral annular and tricuspid annular velocities. However, when stepwise multiple regression analysis was performed, only deceleration time of early RV filling ($R^2=0.558$, $p=0.001$) and RV area shortening fraction ($R^2=0.637$, $p=0.001$) were identified as independent predictors of peak VO_2 in patients with CHF.

Conclusion: Echocardiographic parameters of RV systolic and diastolic performance were found to be the most important determinants of peak VO_2 in CHF patients. These observations support the hypothesis that RV function significantly contributes to exercise intolerance in CHF.

RELATIONSHIP BETWEEN ARTERIAL COMPLIANCE AND DIASTOLIC FUNCTION OF THE LEFT VENTRICLE, IN YOUNG PATIENTS WITH WHITE COAT HYPERTENSION, USING THE STIFFNESS INDEX AND TISSUE DOPPLER IMAGING

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"White coat" effect is considered an alert reaction, which increases basal blood pressure in some individuals when it is measured by a physician—less so when measured by a nurse. We hypothesised that in white coat hypertensive patients (WCH), without any target organ damage, loss of arterial compliance (AC) of the peripheral arteries, should lead to abnormalities of the systolic and diastolic function, of the left ventricle at an early stage of the disease.

Methods: Nine WCH patients (mean age 32 ± 8.36 years) without clinical or echocardiographic signs of impaired left ventricular function, were compared to seven, age and sex matched controls (mean age 32 ± 4.3 years). From apical four chamber projections, the E wave velocity, E/A ratio, isovolumic relaxation time (IVRT), and deceleration time (DT), were measured from transmitral Doppler velocities. From apical long axis projections, (posterior mitral annulus), the peak systolic velocity (Sa), early (Ea) and late (Aa) diastolic velocities, the Ea/Aa ratio were measured with pulsed TDI and analysed off-line with a dedicated software (HDI Lab ver. 1.83f). The E wave velocity corrected for the influence of relaxation as a less load dependent index (i.e. the E/Ea ratio) was also measured. Stiffness Index (SI) for the determination of the AC was measured by the Digital Volume Pulse (DVP) photoplethysmographic method. Statistical analysis was performed using the unpaired Student's t test, and the results are expressed as mean \pm SD.

Results: In WCH patients, no difference was detected in E and A wave velocities, E/A ratio, IVRT and DT when compared to controls. Using pulsed TDI, the Ea velocity, the Sa velocity, the Ea/Aa ratio, the Aa velocity, and the E/Ea ratio were similar in both groups. However the SI was increased in WCH patients (10.6 ± 2.5 versus 7.7 ± 0.6 $P < 0.05$).

Conclusion: Our preliminary data suggest that there is an impaired arterial compliance of the peripheral arteries, in the absence of any diastolic or systolic left ventricular dysfunction in young patients with white coat hypertension.

ECHOCARDIOGRAPHIC MONITORING OF PATIENTS WITH HEART FAILURE SUPPORTED WITH A PULSATILE LEFT VENTRICULAR ASSIST DEVICE

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Left ventricular assist devices (LVADs) are being used increasingly to maintain patients awaiting transplantation due to severe heart failure from left ventricular (LV) systolic dysfunction. The devices can support LV function, enable patient rehabilitation and facilitate discharge from hospital. We have monitored 19 patients with dilated cardiomyopathy during support with pulsatile TCI Vented Electric Heartmate® 1 LVADs. During LVAD support, the LV was decompressed but continued to contract asynchronously throughout the LVAD cycle. Mitral valve opening always coincided with LV diastole but the filling pattern varied according to the phase relationship with the LVAD. Mitral flow

occurred continuously throughout diastole when this phase corresponded to device filling. Usually, the native aortic valve did not open at rest and the LV and LVAD functioned 'in series'. During the period of device support the LV systolic function (ejection fraction) of five patients with dilated cardiomyopathy progressively improved allowing explantation of the device without the need for heart transplantation. In these cases the aortic valve opened at rest or after exercise such that the LV and device were functioning 'in parallel'. Device related complications detected by echocardiography included post-operative pericardial effusions (12), acquired regurgitation of the native aortic valve (2) and regurgitation of the device inlet valve (6) which necessitated device replacement in 2 cases. With wider use of LVADs and the trend to discharge patients from hospital during support, it will be essential for Echocardiographers and Cardiologists to be familiar with the expected findings and complications that may occur in patients supported with these devices.

LEFT VENTRICULAR ENLARGEMENT IS NOT INEVITABLE WITH CHRONIC SEVERE MITRAL REGURGITATION

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Background: Dilatation and volume overload of the left ventricle (LV) is considered an important marker of severity of chronic mitral regurgitation (MR). In our experience, however, severity of MR does not correlate well with LV internal dimensions or volumes. We examined this relationship in a transthoracic echocardiographic study of 48 patients with chronic severe MR due to degenerative mitral valve disease.

Methods: MR was quantified by regurgitant fraction (RF) using a previously validated method combining pulse wave Doppler and dimensions at the aortic and mitral annuli. Severe MR was defined as $\text{RF} > 55\%$. LV end-diastolic and end-systolic diameter diameters (EDD and ESD) were measured from parasternal long-axis m-mode. LV ejection fraction (EF), end-diastolic volume (EDV), and end-systolic volume (ESV) were measured using apical biplane method of discs. Enlargement was defined as $\text{EDD} > 5.9$ cm and > 5.2 cm, $\text{ESD} > 4.0$ cm and > 3.5 cm, $\text{EDV} > 166$ ml and > 129 ml, $\text{ESV} > 67$ ml and > 59 ml for male and female respectively.

Results: Age range was 22 to 83 years, mean \pm SD 61 ± 13 ; 69% male; 79% sinus rhythm; 33% in NYHA III/IV. Mean \pm SD measurements for the echo characteristics were as follows: EDD 5.74 ± 0.86 cm, ESD 3.69 ± 0.87 cm, EDV 159 ± 52 ml, ESV 63 ± 27 ml and EF $60 \pm 8\%$. The RF ranged from 56–93%, mean \pm SD $75 \pm 10\%$. No significant correlation was seen between RF and age, height, body surface area, duration of MR or rhythm. Prevalence of LV enlargement corrected for height and gender was 58% for EDD, 38% for ESD, 50% for EDV and 38% for ESV.

Conclusions: The data from our cohort indicates that in patients with chronic severe MR LV dilatation is not universal. Factors other than the degree of MR may be important in determining the extent of ventricular remodelling.

THREE-DIMENSIONAL ECHOCARDIOGRAPHY IS SUPERIOR TO MULTIPLANE TOE IN THE PRE-OPERATIVE ASSESSMENT OF MITRAL VALVE MORPHOLOGY

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Background: Three-dimensional (3D) reconstruction may improve the diagnostic accuracy of multiplane transoesophageal echocardiography (TOE) in the assessment of mitral valve morphology prior to valve repair surgery.

Methodology: TOE and 3D reconstruction were performed during routine assessment prior to mitral valve repair surgery. Using the Carpentier nomenclature (A1, A2, A3, P1, P2, P3, Anterolateral commissure and Posteromedial commissure) the surgeon classified segmental leaflet function as normal, prolapse, flail, tethered or perforated. Experienced operators blinded to the surgical findings evaluated anonymised TOE and 3D studies using the same nomenclature. Using surgical data as the gold standard, 3D and TOE evaluations were compared for accuracy of morphological assessment in terms of identification and localisation of exact pathology.

Results: 60 patients were studied [mean (SD) age 59.33 (12.79) years; 63% male; 85% in sinus rhythm; 60% under general anaesthesia, 40% under sedation]. 40 patients had degenerative valve disease, 8 endocarditis and 12 ischaemic regurgitation. A total of

480 segments (8 segments for each patient) were analysed. 3D was superior to TOE in achieving adequate visualisation of segments (97.5% of segments c.f. 86%; $p<0.001$) independent of cardiac rhythm and anaesthesia or sedation. The difference in visualisation was predominantly at the commissures (3D visualising 113/120 c.f. 59/120 commissures with TOE; $p<0.001$). Even when visualisation was adequate, 3D matched more closely to the surgical findings (3D accurate in 88% of visualised segments c.f. 80% segments by TOE; $p<0.001$). 3D was significantly more accurate in the diagnosis and localisation of anterior leaflet and commissural pathology ($p=0.046$ for A1, $p=0.002$ for A2, $p=0.005$ for A3 and $p<0.001$ for both commissures) but not of the posterior leaflet.

Conclusions: In this study 3D was superior not only for complete visualisation of the mitral valve but also for the accurate localisation and identification of pathology, particularly of the anterior leaflet and commissures.

EFFECTIVE ORIFICE AREA INCREASES WITH TRANSVALVULAR FLOW IN ALL GRADES OF AORTIC STENOSIS

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Background: The effect of increasing flow upon continuity effective orifice area in aortic stenosis remains controversial. We examined this in a large group of patients.

Method: 101 patients with aortic stenosis (AS) and normal resting left ventricular systolic function underwent stress echocardiography. Dobutamine was infused in 5 minute increments of 5 mcg/kg/min to a maximum of 20 mcg/kg/min. Pulsed Doppler in the left ventricular outflow tract and continuous wave Doppler across the aortic valve were recorded at baseline and at each stage. Transaortic flow was calculated as stroke volume/systolic ejection time, where $SV=VTI_{LVO} \times CSA_{LVO}$ for each stage. Effective orifice area (EOA) was calculated by the classical continuity equation.

Results: The mean (SD) baseline flow was 235 (72.5) ml/s, increasing to 347 (103.5) ml/s at peak stress ($p<0.0001$). The baseline peak aortic velocity was 3.6 (0.8) m/s and this increased by 1.0 (0.42) m/s. The EOA at rest was 0.9 (0.3 cm²) and this increased at peak in 89 patients and fell or was unchanged in 12. The mean increase was 0.23 cm² (95% CI 0.19–0.28, $p<0.0001$). At baseline, 41 patients had severe AS (EOA<0.8 cm²), 44 moderate (0.8–1.2 cm²) and 16 mild (EOA >1.2 cm²). The absolute increase in EOA was 0.18, 0.27 and 0.21 cm² respectively ($p=ns$ by ANOVA), but the percentage increase was 32.1%, 25.9% and 11.7% ($p=0.014$). Comparing baseline and peak values, the proportion with severe AS fell from 41% to 20%, while the number with apparently mild AS rose from 16% to 40%.

Conclusion: In most patients with all grades of aortic stenosis, effective orifice area is flow-dependent. Errors of classification could be made unless transaortic flow is taken into account when effective area is calculated.

LEFT VENTRICULAR LONG AXIS FUNCTION DECLINES WITH INCREASING SEVERITY OF AORTIC STENOSIS

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Background: Left ventricular function does not always recover after valve replacement for aortic stenosis. It is possible that left ventricular long axis function may provide an earlier guide to left ventricular dysfunction in AS than conventional measures.

Method: We studied long axis (LA) function in 123 patients with aortic stenosis and normal left ventricular systolic function (fractional shortening >27% and no wall motion abnormality). LA systolic excursion of the septum and lateral wall was measured in M-mode in the apical 4-chamber view. 94 patients also underwent exercise testing on the Modified Bruce protocol.

Results: Mean peak transaortic velocity was 3.9 m/s (range 2.1–6.0) and mean effective orifice area (EOA) was 0.9 cm² (0.4–1.6). Mean septal LA excursion was 10.8 (2.7) mm, mean lateral LA excursion 12.7 (3.0) mm. Septal and lateral LA excursion both correlated directly to EOA ($p<0.0001$) and inversely to peak transaortic velocity ($p=0.0005$) and mean transaortic resistance ($p=0.0008$). Septal LA excursion also correlated to mitral diastolic E:A ratio ($p=0.0008$), but not to left ventricular mass index.

| Subgroup: | Mild | Moderate | Severe | p (ANOVA) |
|------------------------|------|----------|--------|-----------|
| EOA (cm ²) | >1.2 | 0.8-1.2 | <0.8 | |
| n | 10 | 59 | 54 | |
| Sept LA exc (mm) | 13.5 | 11.4 | 9.6 | <0.0001 |
| Lat LA exc (mm) | 15.3 | 13.7 | 11.3 | <0.0001 |

On exercise testing, 42 patients stopped because of limiting breathlessness, chest pain or dizziness. Mean (SD) septal LA excursion was 9.9 (2.5) mm in patients with symptoms and 11.2 (3.6) mm in patients without ($p=0.035$). Mean lateral LA excursion was 12.1 (3.2) mm and 13.1 (3.9) mm respectively ($p=0.19$).

Conclusion: Septal and lateral long axis excursion decrease in relation to the grade of aortic stenosis even if transverse systolic function is normal. Septal long axis function may relate to exertional symptoms.

A COMPARISON OF EXERCISE AND DOBUTAMINE IN FLOW AUGMENTATION ACROSS MECHANICAL MITRAL VALVES

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The objective of this study was to compare the effects of dobutamine and exercise on echocardiographic volumetric and velocity indexes of left ventricular filling in patients post Mitral valve replacement.

Methods: 16 patients who had recently undergone mechanical MVR (3 months \pm 1 month) were studied. Haemodynamic variables, 2D echocardiographic and Doppler mitral/aortic flows were recorded at rest. These same readings were then repeated during bicycle ergometry, performed for a maximum of 4 three-minute stages, each stage increasing in workload by 20 Watts. After 30 minutes rest the same patients were then subjected to dobutamine stress, administered in three-minute stages with incremental doses being given up to a max. 40 μ g/Kg/min dependent on heart rate.

Results: A substantial increase in mean blood pressure was seen in exercise, whereas dobutamine remained relatively unchanged (+15.7 mm Hg vs -0.5 mm Hg $p<0.0001$). Maximum/mean pressure gradient increased in both stresses, although the increase seen in exercise was significantly greater than dobutamine (+7.6 vs. +0.7 mm Hg and, 4.8 vs. 1.05 mm Hg respectively). Conversely the diastolic filling time was statistically longer with dobutamine stress.

Conclusion: LV diastolic filling was significantly different, when both stresses were compared for similar stroke volumes at comparable heart rates. Prolongation of the diastolic filling time seen with dobutamine compared to exercise, may be related to the reduced afterload, increased augmentation on myocardial contraction/relaxation or improved chamber compliance.

| Variables | Exercise | Dobutamine | p Value |
|-----------------------------------|----------|------------|---------|
| Mean blood pressure (mmHg) | 116.1 | 96.1 | <0.0001 |
| Cardiac output (l/min) | 7104 | 7111 | NS |
| Heart rate (bpm) | 107.5 | 105.6 | NS |
| Diastolic filling time (ms) | 265.2 | 302.7 | <0.0012 |
| Total velocity time integral (cm) | 16.2 | 16.3 | NS |
| Max. Pressure gradient (Vmax) | 15.95 | 9.05 | <0.005 |
| Mean pressure gradient (Vmean) | 8.55 | 4.75 | <0.008 |

WALL MOTION AND PERFUSION ASSESSMENT USING REAL TIME MYOCARDIAL CONTRAST DOBUTAMINE STRESS ECHOCARDIOGRAPHY

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Aim: To assess whether simultaneous contrast echocardiographic wall motion and perfusion analysis can predict coronary artery stenosis.

| | Sens. | Spec. | PPV | NPV |
|--------|-------|-------|------|------|
| SWM | 85.7% | 90.3% | 0.91 | 0.85 |
| CWM | 77.1% | 93.6% | 0.93 | 0.78 |
| MP | 22.9% | 96.8% | 0.89 | 0.53 |
| CWM+MP | 77.1% | 90.3% | 0.90 | 0.78 |

Methods: Myocardial Contrast Dobutamine Stress Echocardiography (MCDSE) was performed on 22 patients with known 1 or 2 vessel coronary artery stenosis (>50%) using the Cadence Contrast

Imaging (CCI) system (Sequoia C256, Acuson). Contrast images were acquired at baseline and peak stages during DSE using intravenous infusion of Optison (Molecular Biosystems Inc.). Images were acquired via apical and parasternal windows and interpreted visually for standard wall motion (SWM), CCI wall motion (CWM), and reversible myocardial perfusion defect (MP) after blinding to angiographic data.

Results: The 22 patients had a total of 35 coronary stenoses (17 LAD, 11 RCA, 7 Circumflex). Sensitivity, specificity, positive and negative predictive value of SWM, CWM, MP, and combined CWM and MP were as follows:

Conclusions: (1) Real time perfusion imaging enables wall motion interpretation with reasonable sensitivity and good specificity. (2) Reversible myocardial perfusion defects at peak stress are insensitive for coronary artery stenosis using this protocol.